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RAINFALL PROBABILITY ANALYSIS FOR BAPATLA REGION OF ANDHRA PRADESH USING VISUAL BASIC

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ABSTRACT

Rainfall forecasting is the prominent aspect of hydrologic investigation. Rainfall distribution is a function of time. Therefore, it is important to investigate the rainfall data with regard to expected rainfall in relation to plotting position, which gives an anticipated depth of occurrence of rainfall at a given probability level during a specific period. Weekly and monthly rainfall analysis may be helpful in better crop design, specifying and establishing the time of sowing, cultural operations and irrigations of crops grown in a variety of seasons and regions. This problem is applicable in the estimates of rainfall, floods, droughts, storages etc. The design of any hydrologic structure depends upon estimated maximum rainfall for that period.

Probability is a chance or likelihood based on the sampled data. The hydrologic phenomena are highly stochastic and queer in nature, and therefore are amenable to statistical interpretation and probability analysis. Realizing the importance of interpretation of rainfall by way of rainfall probability analysis, this present study "Rainfall Probability Analysis for Bapatla region of Andhra Pradesh using Visual Basic" is taken up to develop probability distribution and frequency curves of annual maximum weekly rainfall data using Log normal distribution and Gumbel distribution, simultaneously developing a Window based program for the suitable probability distribution function.

The present study on "Rainfall Probability" for Bapatla region was done with weekly data of 10 years. The major objective of the analysis is to write such a program which could analyze the rainfall data of any area. In the present case the data for analysis was found to be suiting the Gumbel Distribution. The χ^2 value of Gumbel distribution is in the range, i.e. $\chi^2_{tab} > \chi^2_{cal.}$ So it is suggested to use the Gumbel distribution.

KEYWORDS: Rainfall Probability, Gumbel & Bapatla

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Original Article

INTRODUCTION

Rainfall forecasting is the prominent aspect of hydrology investigation. Rainfall distribution is a function of time. Therefore, it is important to investigate the rainfall data with regard to expected rainfall in relation to plotting position which gives an anticipated depth of occurrence of rainfall at a given probability level during a specific period. Weekly and monthly rainfall analysis may be helpful in better crop design, specifying and establishing the time of sowing, cultural operations and irrigations of crops grown in a variety of seasons and regions. This problem is applicable in the estimates of rainfall, floods, droughts, storages etc. The design of any hydrologic structure depends upon estimated maximum rainfall for that period.

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Soni et. al. (1977) and *Singh and Singh (1978)* in their critical studies on monthly rainfall data of Midnapore Observatory, West Bengal and weekly rainfall data of the Jamalpur block of Bihar respectively, found that Weibull formula gives better fit in the terms of linearity. *Soni (1977)* also observed that the relationship between plotting position and rainfall when plotted on a probability paper could be linearized better, at least in the range of 20 to 80% probability level if square root values of the original data were analyzed. *Senapati et. al. (1979.a)* collected annual maximum daily total rainfall data of 30 years for a station at Bhubaneswar (Orissa) and plotted the frequency curves of annual maximum rainfall data using two different theoretical probability distributions namely log normal distribution and Gumbel distribution.

Singh and Rao (1981) analyzed fifty years of monthly rainfall data from six gauging stations of West Bengal to determine the plotting position considering each monthly time series for all the stations. Individually, the plotting positions for respective rainfall amounts were determined and expected rainfall at 60, 70, 75, 80 and 90 percentage levels of probabilities were estimated.

Tiwari and *Jaswant Singh (1985)* analyzed thirty year rainfall data of Midnapore to develop a deterministic empirical model to forecast monthly cumulative rainfall and showed that the Gompertz curve can be a best fit curve to the data. The coefficient of the mathematical model representing Gompertz curve was ultimately calculated using a smoothing technique. The results showed that this model can be used to forecast the monthly values of precipitation with a reasonable accuracy.

DATA AND METHODOLOGY

The rainfall data for Bapatla region, Guntur district for 10 years (1999-2008) were collected from Meteorological Centre, Agricultural College Farm, Bapatla.

Basic Equations

For the analysis of rainfall data, to fit into a probability distribution function, namely the following distributions were used for analysis based on the equation literature available.

- Normal distribution,
- Lognormal distribution
- Gumbel distribution

Normal Distribution

Log Normal Distribution

This is a transformed normal distribution in which the fruit is replaced by logarithmic value. Its probability density is

$$P(x) = \frac{1}{\sigma_y . e^{y}\sqrt{(2x)}} e^{-(y-\mu_y)^2/2\sigma_y{}^2} \ \ldots \quad (2.1)$$

Where y = ln x, x is the variate, μ_y is the mean of y and $\sigma_y$is the standard deviation of y. Chow has derived the statistical parameters for x as

$\mu = e^{\mu_y} + {\sigma_y}^2/2$

$\sigma = \mu\ (e^{{\sigma_y}^2} - 1)^2$

$a = (e^3\ {\sigma_y}^2 - 3e\ {\sigma_y}^2 + 2)\ C_v^3$

$M = e^{\mu_y}$

$\frac{\mu}{M} = e^{{\sigma_y}^2}/2$

$C_v = (e^{{\sigma_y}^2} - 1)^{1/2}$

$C_s = 3\ C_v = C_v + C_v^3$

Where μ is the mean, σ is the standard deviation, C_s is the coefficient of skewness, M is the median and C_v is coefficient of variation.

For this distribution, annual maximum daily rainfall data transformed to corresponding natural logarithmic values. The return period T was calculated using a Weibull's formula as

$$T = \frac{n+1}{m} \quad (2.2)$$

Where 'n' is the total number of years of record and 'm' is the rank number from the highest value. The data is arranged in descending order.

The annual average maximum daily rainfall, X, the mean of transformed variate, Y, the standard deviation, σ_y, the coefficient of variation, C_v and the coefficient of skewness, C_s are computed as-

$\bar{x} = \sum x/n..$ (2.3)

$\bar{y} = \sum y/n$ (2.4)

$\sigma_y = \{(\sum y^2 - (\sum y)^2/n)/n-1\}^{1/2}$ (2.5)

$c_v = \{\exp(0.1307613) - 1\}^{1/2}$

$c_s = 3\ c_v + c_v^3$

Recurrent interval in years and corresponding percent change (or probability) of occurrence were selected, and corresponding values of frequency factor k were computed. Thus x/X values were obtained by the following formula:

$$\frac{x}{X} = 1 + C_v.k \ \ldots \quad (2.8)$$

Knowing the values of 'x', theoretical annual maximum daily total rainfall for corresponding recurrence interval was computed. The theoretical annual maximum daily total rainfall values along with recurrence interval and percent change are given.

Gumbel Distribution

This distribution results from any initial distribution of exponential type which converges to an exponential function as 'x' increases. The probability density of this distribution is

$$P(X) = 1/C \exp(-(a+x)/c - \exp(-(a+x)/c)) \ldots \quad (2.9)$$

With $\infty<x<\infty$, where 'x' is the variety and a and c are parameters. The cumulative probability is

$$P(X<=x) = \exp(-\exp(-((a+) x/c)) \ldots \quad (2.10)$$

By the method of moments, the parameters have been evaluated as

$a = \gamma c - \mu$ and $c = ((6)^{1/2}/\prod) * \sigma$

Where $\gamma = 0.57721$, which is known as Euler's constant, μ is the mean and σ is the standard deviation. The method of computing the probability of the given extreme values is given by Chow (1) was used in this paper. The frequency factor of the following form was used for assuming recurrence interval

$$K = -(6)^{1/2}/\prod\{\gamma - \ln(\ln(t/(t-1)))\}$$

Thus, theoretical rainfall amounts were computed by

$$x = \bar{x} + \sigma_x$$

The average annual maximum daily rainfall

$$\mu = \bar{x} = \sum x/N$$

σ_y = Standard deviation

Rainfall probability analysis with the felt of a programme in 'Visual Basic' language:

As the data is large, it was appropriate if programming could be done in Visual Basic for all the three distributions. Hence, a single programme was written to cover all the three distribution functions. The programme flow chart is given below. In the beginning, the input data was fed in Microsoft Access. The input data contains the weekly average rainfall for 52 weeks with the help of the data entry form. It contains 53 input boxes, one for the year and 52 for 52 weeks of rainfall. It also contains save button clicking on which the data entered in the form will be posted in the table of MS Access.

Opening the Analysis form, visual basic retrieves data from the table and loads the details into a two dimensional array. With the several commands like, connection, object, command object, and recordset the data is executed, and then again the output is returned Microsoft Excel, where the charts were drawn to different distributions fitted.

Testing of Goodness of Fit of Distributions

- The output frequency tests with the $\chi 2$ test.
- The output $\chi 2_{cal}$ value is compared with the tabulated value.
- If the $\chi 2_{tab} \cong \chi 2_{cal}$ then the corresponding programme is recommended for further prediction of rainfall in that area.
- The graph of depth of rainfall Vs expected frequency was drawn using visual 'C' software.

The flow chart for the analysis is presented in Figure 1

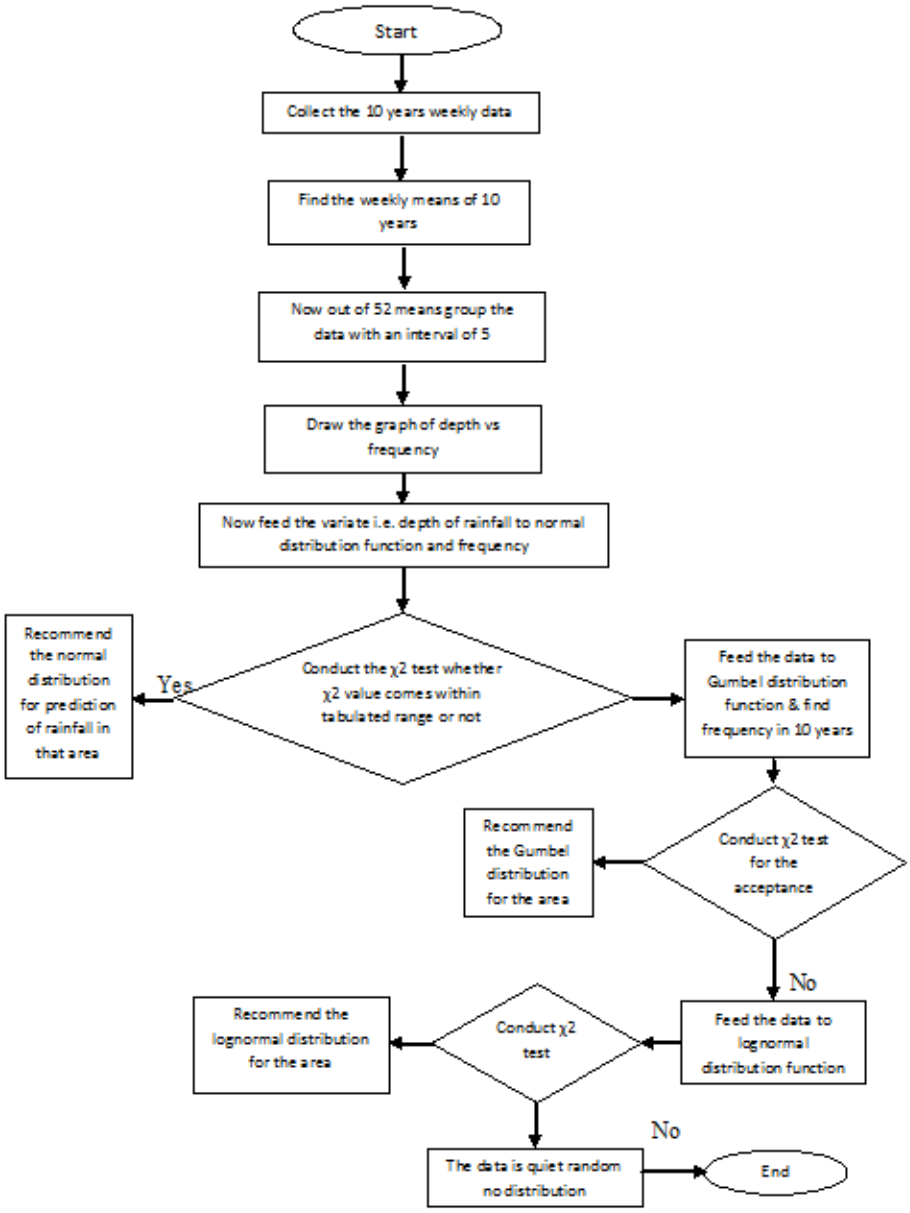

Figure 1: Flow Chart Showing the Login Cal Sequence of Software Developed

RESULTS AND DISCUSSIONS

The analysis was carried out with the collected data as outlined in the results. The data obtained from the analysis are presented and discussed in the following section.

Weekly Rainfall Analysis

The weekly analysis was carried out with the help of Visual Basic program. The collected data of Bapatla on analysis were found not fitting for any of the three distributions. The observed frequency of rainfall, taking in mind the values of class intervals is tabulated and presented in Table 4.1.

Table 4.1: Table Showing the Depth of Rainfall and Observed Frequency

SI.No	Depth	Observed Frequency	Normal Distribution	Log Normal	Chi-Square Distribution	Gumbel Distribution
1	2.5	16	5.578607	0.143808	2.432393	0.9548
2	7.5	12	8.479989	0.371196	2.466377	1.1765
3	12.5	1	9.559764	0.603568	2.467941	1.249
4	17.5	5	9.523479	0.723141	2.463996	1.1906
5	22.5	1	8.822378	0.708069	2.458482	1.0503
6	27.5	1	7.779589	0.606751	2.452514	0.876
7	32.5	2	6.615449	0.476071	2.446493	0.7018
8	37.5	5	5.469219	0.352404	2.44058	0.546
9	42.5	2	4.420151	0.251013	2.434842	0.416
10	47.5	2	3.505835	0.174303	2.429302	0.3122
11	52.5	3	2.736831	0.119019	2.423965	0.2317
12	57.5	1	2.107521	0.080372	2.418827	0.1706
13	62.5	0	1.603698	0.053877	2.413878	0.1249
14	67.5	0	1.207563	0.1886043	2.409109	0.0911
15	72.5	1	0.900808	-0.1044631	2.404509	0.0662

The data were plotted in MS excel and is shown in Figure 2. The trend is irregular without proper skins to suit to any of the distribution functions' shape.

The Outputs from Visual Basic Programme

The programme written in visual Basic is run to know the result of distributions fitted to the rainfall data. The results are presented in the form of tables and graphs

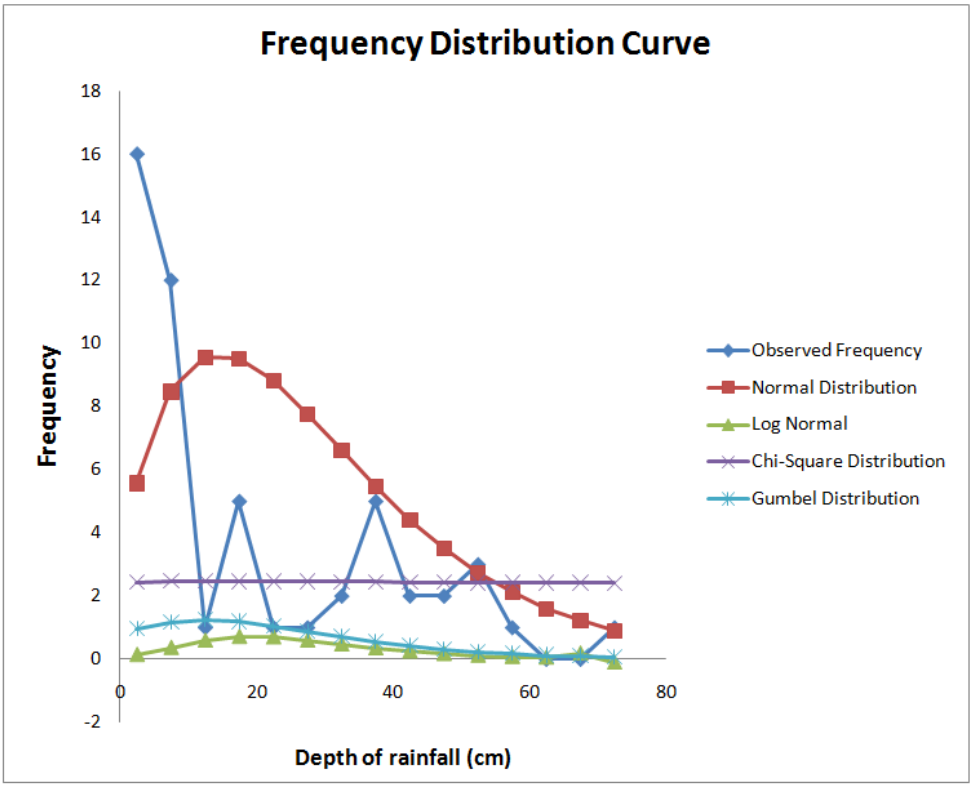

Figure 2: Rainfall Depth Predicted by different Probability Distributions

On conducting χ^2 test the value comes out to be 436.9118, which is too large to accept.

Ignoring low rainfall depths:

The χ^2 test value for this distribution is 52.24788 which are also too high to accept.

The χ^2 test value for this distribution is 127.27 which are again too high to accept.

CONCLUSIONS

The present study on "Rainfall Probability" for Bapatla region was done with weekly data of 10 years. The major objective of the analysis is to write such a programme, which could analyze the rainfall data of any area. In the present case, the data for analysis was found to be suiting the Gumbel Distribution. The χ^2 value of Gumbel distribution is in the range, i.e. $\chi^2_{tab} > \chi^2_{cal.}$ So, it is suggested to use the Gumbel distribution.

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